CLAIMS

1. A method of treating, in a gas treatment plant, a feed gas stream comprising hydrocarbon gas and acid gas, the method comprising:

(a) measuring an acid gas concentration in the feed gas stream to determine an acid gas fraction;

(b) if the acid gas fraction is less than a first threshold, cooling the feed gas stream and liquefying acid gas in said feed gas stream only in a first feed refrigeration unit to generate a two-phase stream;

(c) if the acid gas fraction is greater than the first threshold,

cooling a first portion of the feed gas stream and liquefying acid gas in said first portion using the first feed refrigeration unit to generate the first two-phase stream, and

cooling a second portion of the feed gas stream and liquefying acid gas in said second portion using a second feed refrigeration unit to generate a second two-phase stream, whereby an acid gas fraction of a gaseous portion of the first two-phase stream generated in step (c) is substantially the same as an acid gas fraction of a gaseous portion of the second two-phase stream;

(d) separating the liquefied acid gas from the two-phase stream, or if the acid gas fraction is greater than the first threshold, separating the liquefied acid gas from the first and second two-phase streams, to create a vapor stream having a constant acid gas fraction regardless of how many feed gas refrigeration units are used;

(e) separating from the vapor stream, primarily by freezing, substantially all of the acid gas remaining in the vapor stream to create a hydrocarbon gas stream;

(f) melting the frozen acid gas;

(g) removing the melted acid gas and the liquefied acid gas, which together form a bottoms stream; and

(h) removing the hydrocarbon gas stream.

2. The method of claim 1, wherein the second feed refrigeration unit has a performance characteristic in common with the first feed refrigeration unit.

3. The method of claim 2, wherein the performance characteristic is cooling capacity of the first feed refrigeration unit or a power rating of the source of refrigeration.

4. The method of any one of claims 1-3, wherein step (g) comprises:

combining the melted acid gas and the liquefied acid gas to form the bottoms stream; and

pumping the bottoms stream using a first bottoms stream pump and at least one additional bottoms stream pump, wherein the number of the additional bottoms stream pumps used is a function of the acid gas fraction.

5. The method of claim 4, wherein each of the at least one additional bottoms stream pump has a performance characteristic in common with the first bottoms stream pump, and wherein the performance characteristic is a flow rate of the first bottoms stream pump or a discharge pressure of the first bottoms pump.

6. The method of any one of claims 1-5, wherein at least steps (e) and (f) are performed in a cryogenic distillation column.

7. The method of any one of claims 1-6, further comprising:

before performing step (g), heating the bottoms stream to remove residual hydrocarbon gas therefrom, wherein heating the bottoms stream includes

heating the bottoms stream using a first bottoms stream heat exchanger and at least one additional bottoms stream heat exchanger, wherein the number of the additional bottoms stream heat exchangers used is a function of the acid gas fraction.

8. The method of claim 1, further comprising:

if the acid gas fraction is greater than a second threshold that is greater than the first threshold,

cooling a first portion of the feed gas stream and liquefying acid gas in said first portion using the first feed refrigeration unit to generate the first two-phase stream,

cooling a second portion of the feed gas stream and liquefying acid gas in said second portion using a second feed refrigeration unit to generate a second two-phase stream, and

cooling a third portion of the feed gas stream and liquefying acid gas in said third portion using a third refrigeration unit to generate a third two-phase stream, whereby an acid gas fraction of a gaseous portion of the first, second, and third two-phase streams are substantially the same; and

separating the liquefied acid gas from the first, second, and third portions of the feed gas stream to create the vapor stream.

9. The method of claim 8, wherein the second threshold is 58 mole% acid gas.

10. The method of any one of claims 1-9, wherein the first threshold is 40 mole% acid gas.

11. A method of designing and constructing a hydrocarbon gas treatment plant, comprising:

establishing a target hydrocarbon production range for a hydrocarbon gas meeting a required product specification;

designing and constructing a cryogenic distillation column with a vapor capacity to meet the target hydrocarbon production range;

incorporating a variable feed refrigeration system to cool an inlet feed of the hydrocarbon gas, the variable feed refrigeration system designed to handle the target hydrocarbon production range and a wide range of contaminant concentrations in the inlet feed, the variable feed refrigeration system including

a first feed refrigeration unit, and

a second feed refrigeration unit,

wherein if an acid gas fraction of the inlet feed is less than a first threshold, only the first feed refrigeration unit is used to cool the inlet feed and liquefy acid gas in the inlet feed, and

wherein if the acid gas fraction of the inlet feed is greater than the first threshold, a first portion of the inlet feed is cooled, and acid gas in said first portion is liquefied using the first feed refrigeration unit to generate a first two-phase stream, and a second portion of the inlet feed is cooled, and acid gas in said second portion is liquefied using the second feed refrigeration unit to generate a second two-phase stream, wherein an acid gas fraction of a gaseous portion of the first two-phase stream is substantially the same as an acid gas fraction of a gaseous portion of the second two-phase stream;

incorporating a variable bottoms heating system capable of handling heating duties associated with the wide range of contaminant concentrations in the inlet feed; and

incorporating a variable bottoms pumping system capable of handling liquid flows associated with the wide range of contaminant concentrations in the inlet feed.

12. The method of claim 11, further comprising designing and constructing an overhead refrigeration and separation system with a vapor capacity to meet the target hydrocarbon production range.

13. A gas treatment system for treating a feed gas stream including hydrocarbon gas and acid gas, comprising:

a first feed refrigeration unit and a second feed refrigeration unit;

wherein if an acid gas fraction of the feed gas stream is less than a first threshold, only the first feed refrigeration unit is used to cool the feed gas stream and liquefy acid gas in the feed gas stream to generate a two-phase stream;

wherein if the acid gas fraction of the feed gas stream is greater than the first threshold,

using the first feed refrigeration unit to cool a first portion of the feed gas stream, and liquefy acid gas in said first portion, to generate a first two-phase stream, and

using the second feed refrigeration unit to cool a second portion of the feed gas stream, and liquefy acid gas in said second portion, to generate a second two-phase

stream, wherein an acid gas fraction of a gaseous portion of the first two-phase stream is substantially the same as an acid gas fraction of a gaseous portion of the second two-phase stream;

a separator that separates the liquefied acid gas in the two-phase stream, or the first and second two-phase streams, to create a vapor stream having a composition that is substantially constant regardless of a number of the feed refrigeration units that are activated;

a cryogenic distillation column that separates by freezing substantially all of the acid gas remaining in the vapor stream to create a hydrocarbon gas stream and an amount of frozen acid gas;

a bottoms stream heat exchanger that heats a bottoms stream that includes the liquefied acid gas and the amount of frozen acid gas after it has been melted; and

at least one bottoms stream pump that removes the melted acid gas and the liquefied acid gas, which together form a bottoms stream, wherein the number of the at least one bottoms stream pumps is selected as a function of the first acid gas fraction or the second acid gas fraction.

14. The gas treatment system of claim 13, wherein the second feed refrigeration unit has a performance characteristic in common with the first feed refrigeration unit, and wherein the performance characteristic is cooling capacity of the first feed refrigeration unit or a power rating of the source of refrigeration.

15. The gas treatment system of any one of claims 13-14, wherein at least two bottoms stream pumps are utilized, and wherein each of the bottoms stream pumps being utilized have a common performance characteristic.

16. The gas treatment system of claim 15, wherein the performance characteristic is a flow rate or a discharge pressure.

17. The gas treatment system of any one of claims 13-16, wherein the heating duty of bottoms stream heat exchangers being utilized is selected as a function of the first acid gas fraction or the second acid gas fraction.

18. The gas treatment system of any one of claims 13-17, wherein the first threshold is 40 mole% acid gas.

19. The gas treatment system of any one of claims 13-18, further comprising a third feed refrigeration unit;

wherein if the acid gas fraction is greater than a second threshold that is greater than the first threshold,

using the first feed refrigeration unit to cool a first portion of the feed gas stream, and liquefy acid gas in said first portion, to generate a first two-phase stream,

using the second feed refrigeration unit to cool a second portion of the feed gas stream, and liquefy acid gas in said second portion, to generate a second two-phase stream, and

using the third feed refrigeration unit to cool a third portion of the feed gas stream, and liquefy acid gas in said third portion, to generate a third two-phase stream,

wherein an acid gas fraction of a gaseous portion of each of the first, second, and third two-phase streams are substantially the same;

and

separating the liquefied acid gas from the first, second, and third portions of the feed gas stream to create the vapor stream.

20. The gas treatment system of claim 19, wherein the second threshold is 58 mole% acid gas.